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Art. XX.—*The Influence of Gaseous Pressure on Growth.*

(Preliminary Communication).

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The British Association for the Advancement of Science granted the sum of £50 for the purpose of carrying out a research, "On the Influence of Varying Percentages of Oxygen, and of Various Atmospheric Pressures upon Geotropic and Heliotropic Irritability and Curvature."

This sum was expended on apparatus necessary for the above research, which, for the most part had to be obtained from England, and some delay was experienced owing to difficulties arising from the war. In consequence work so far has been mainly of a preliminary character, but a description of the apparatus employed and a summary of the results obtained to date may be of a little interest.

According to Pfeffer (Pfeffer's Physiology of Plants, Vol. II., p. 114):—"A mere rise of gaseous pressure, if sufficiently great, will produce a retardation and ultimate cessation of growth."

He explains this by stating that a high gaseous pressure outside the plant will antagonise turgor. This could only be a temporary effect, since the protoplasm and the cell wall are permeable to oxygen and nitrogen in solution, so these gases will pass through until the partial pressure of the dissolved gases inside the cell produces an increased osmotic pressure corresponding to the increased gaseous pressure outside the cell, thus producing a gaseous equilibrium.

Jaccard (Rev. Gen. d.Bot., 1893) states that growth in air at from 3-6 atmospheres, is not retarded, and may even in some cases be accelerated.

In order to test these results and those of other observers, I have been performing some experiments under more favourable conditions than was previously the case. It is important that the observations should be made under conditions where immediate responses can be observed in short intervals of time; this can only be done by the aid of the horizontal microscope watching the growth of seedlings in a pressure chamber.

The seedling, the growth of which was to be determined, was fixed to the roof of a pressure chamber by means of plasticene. In the first observations the seedling was fixed to a plate of cork. A curious error was noted—namely, the expansion and contraction of the cork under varying pressures gave apparent growth movements to the seedlings which did not actually take place. It is better to fix seedling to plasticene by means of metal rods, test experiments showed this was not affected by varying gas pressures.

The radicle was so arranged, that it could be clearly seen from the exterior through the glass ends of the chamber.

The air was kept constantly moist by means of a lining of wet cotton wool. A gauge was attached which registered the pressure to which the seedling was subjected. The chamber was connected to a high pressure pump, and so a pressure of any desired value could be produced in it.

A horizontal microscope was used for the readings. It was levelled carefully, and the tip of the root of the seedlings was focussed on to a scale in the eyepiece of the microscope. The divisions on the scale = .064 of a mm. In order to be as accurate as possible, the eye should be kept at the same level at each reading. To ensure this, a rod of certain length was placed in the same position, and the observer's chin rested on it at each reading. The initial position having been read, the seedling is left for one hour, and then its position is again read; this gives directly the amount of growth in fractions of a mm. during that time.

Before subjecting any seedling to pressure, the rate of growth in air was first determined, for this varies according to the individual, and having obtained its rate of growth in air a pressure of known amount was developed in the chamber, and readings were taken at intervals of an hour.

The effect of the pressure does not manifest itself immediately on the growth, at any rate such pressures as I have experimented with, so apparently the direct mechanical effect of increasing the gaseous pressure upon turgor is practically negligible as a factor which influences growth, contrary to Pfeffer's suggestion.

Generally in one day retardation became noticeable, the amount of retardation being dependent on the pressure; broadly speaking, the higher the pressure the greater the retardation.

It seems that at such pressures as I have experimented with, this retardation is not permanent, but the plant accommodates itself to the pressure and the rate of growth is gradually raised.

The temperature was noted throughout the experiments.

Not only does a fluctuation in the temperature affect the rate of growth, but also some seedlings appear to have inherently a higher rate of growth than others. Nevertheless, the effect of raised gaseous pressure is a relatively constant one, irrespective of temperature or of the inherent rate of growth of the seedling.

The seedlings used for all the experiments have been *Pisum arvense* (field pea), and so far as possible I have chosen those of about equal age and size.

Whether the retardation caused by increased gaseous pressure is due to an increase in the partial pressure of the dissolved oxygen or not has still to be determined.

Jentys found that oxygen under a pressure of from 3-4 atmospheres (= the same density as in air under a pressure of from 14-19 atmospheres) caused retardation of growth.

Since, however, air under 3-4 atmospheres pressure produces a similar retardation this is not due wholly to the increased oxygen pressure, but is due in part at least to increased gaseous pressure.

Summary of Results.

I.—Average rate of growth in air = .275 mm. per hour.

II.—Atmospheric Air + 15 lbs.

	Temp. °C.	Rate of growth per hr. mm.
(a) Beginning of experiment	16	.32
End of 1st day	16	.25
	∴ retardation =	.07 in 1 day.
(b) Beginning of experiment	14	.192
End of 1st day	16	.097
	∴ retardation =	.095 in 1 day.

III.—Atmospheric Air + 30 lbs.

	Temp. °C.	Rate of growth per hr. mm.
(a) Beginning of experiment	13.5	.25
End of 1st day	14	.128
	∴ retardation =	.122 per hr.
(b) Beginning of experiment	15	.448
End of 1st day	14	.32
	∴ retardation =	.128

IV.—Atmospheric Air + 45 lbs.

		Temp. °C.	Rate of growth per hr. mm.
(a)	Beginning of experiment	14.5	.25
	End of 1st day	16	.019
		∴ retardation =	.231
(b)	Beginning of experiment	20	.67
	End of 1st day	21	.128
		∴ retardation =	.542
(c)	Beginning of experiment	17	.704
	End of 1st day	18.5	.12
		∴ retardation =	.584

Complete Set of Readings for One Seedling.

Atmospheric Pressure + 15 lbs.

Seedling in Air.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(a)	14	9.25	0	
		12.10	.95	.192
(b)	14	12.20	1	
		1.40	1.5	.226

Atmospheric Pressure + 15 lbs.

	Temp. °C.	Time read.	mm.	1 hours' growth m.m.
(a)	14.5	1.40	1.5	
		2.40	1.8	.192
(b)	14.5	2.40	1.8	
		3.50	2.2	.192
(c)	14.5	3.55	2.2	
		4.55	2.45	.16
(d)	12†	5.20	2 55	
		9	5.3	.097
	†Minimum temperature.			
(e)	16	9.10	1	
		10.10	1.17	.097
(f)	16	10.10	1.2	
		11.30	1.4	.096
(g)	16	11.30	1.4	
		12.55	1.65	.097

ATMOSPHERIC PRESSURE + 30 LBS.

Seedling in Air.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(a)	11.5	9.15	0	
		10.15	.3	.192
(b)	14	10.15	.3	
		11.25	.3	.32
(c)	14	11.25	.9	
		12.25	1.4	.32

ATMOSPHERIC PRESSURE + 30 LBS.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(a)	14.5	12.30	1.4	
		1.30	2.1	.448
(b)	15	1.30	2.1	
		2.30	2.8	.44
(c)	15	2.30	2.8	
		3.30	3.6	.51
(d)	15	3.30	3.6	
		5	4.9	.512
(e)	10†	5	0*	
		9.15	8.4*	.32

† Minimum temperature. * Pressure fallen 20 lbs.

(f)	12	9.25	0	
		10.25	.5	.32
(g)	13	10.25	.5	
		11.25	1.05	.35
(h)	14	11.30	1	
		12.40	1.6	.32
(i)	14	12.40	1.6	
		1.50	2.2	.32
(j)	14.5	1.50	2.2	
		2.50	2.7	.32
(k)	15	2.50	2.7	
		3.50	3.2	.32
(l)	15	3.50	3.2	
		4.50	3.8	.38
(m)	10†	5.5	0*	
		9.5	6.4*	.25

† Minimum temperature. * Pressure fallen to 20 lbs.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(n)	12	9.5	1	
		10.5	1.35	.224
(o)	13	10.5	1.3	
		12.5	2.05	.226
(p)	13	12.5	2	
		12.5	2.75	.224

ATMOSPHERIC PRESSURE + 45 LBS.

Seedling in Air.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(a)	20.5	11.5	1	
		12.5	2.1	.70
(b)	20.5	12.5	2	
		1.5	3	.64
(c)	20	1.5	3	
		1.50	3.85	.70

ATMOSPHERIC PRESSURE + 45 LBS.

	Temp. °C.	Time read.	mm.	1 hours' growth mm.
(a)	20	2	1	
		3	2.05	.67
(b)	20	3	2.05	
		5.55	5.25	.67
(c)		6	1*	
		10.15	gr. off scale*	

* Pressure fallen 35 lbs.

(d)	20	10.30	1	
		11.30	1.09	.057
(e)	20	11.30	1.2	
		12.30	1.25	.032
(f)	20	12.30	1.2	
		1.40	1.42	.098
(g)	20	1.40	1.4	
		2.40	1.6	.128
(h)	21	2.45	1.6	
		3.45	1.85	.16
(i)	21	3.45	1.8	
		4.45	2.15	.16
(j)	12†	4.50	1	
		10.10	4.45*	.08

† Minimum temperature. * Pressure fallen to 28 lbs.